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Wheat Yield and Quality as Related to Early and Late Season Irrigation Management

by

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Summary:

Four dates of first irrigation were imposed on Garland hard red winter wheat in 4 x 20 m plots near Minidoka, Idaho, in 1997 and 1998. Four dates of last irrigation were also tested (three in 1997). Four replications of each treatment were located in a randomized complete block design. Irrigation was by shallow buried drip tape on the early season trials and by drip tape and plot sprinkler in the late season irrigation cutoff study. Irrigation water management was by watermark granular matrix sensors and periodic gravimetric sampling. Crop yield and quality measurements were made for each plot. Best yield was obtained when the first irrigation was as early as water was available in the spring and for last irrigation at soft dough state with a full soil profile. Crop quality measurements were not statistically different with treatment except for the latest early season irrigation and the earliest late season irrigation.

Keywords:

Irrigation scheduling, crop yield, crop quality, drip irrigation

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INTRODUCTION

Yield and quality of spring grain are strongly influenced by irrigation water management. For optimum crop yield and quality, the correct amount of water must be applied at the correct time. Crop stress produced by either under or over-irrigation can reduce both yield and quality. Quality factors of importance are test weight and kernel size. Water management is critical to yield and quality factors in three time periods: early season to establish vigorous growth and enhance later tillering; mid-season at flowering, to properly fill heads and produce yields with optimum water use efficiency , and in late season to avoid over-irrigation and resulting reduction in grain quality.

Previous research on mid-season management has shown the necessity of avoiding crop water stress during the boot/flowering period. Previous research and extension efforts have also shown that proper timing of the last irrigation can improve yield and test weight while reducing the incidence of "black tip" and other fungal diseases resulting from excess late season watering. However, additional information about yield and quality effects of water cutoff earlier than normally assumed optimum would be helpful, particularly in years with short water supply or in high lift pumping areas. For example, in high-lift areas, reduced pumping costs may produce a higher net income with fewer irrigations than would normally be considered optimum.

Of the three critical periods, the least is known about effects of early season water management (e.g. timing of the first spring irrigation) on subsequent crop yield, quality and water use efficiency. Early season growth determines the number of tillers and heads available for later filling. In years with low spring soil moisture, early growth can be retarded and yield depressed. This is particularly a problem in years with an early, dry spring where the crop may be excessively stressed before water can be legally delivered by canal systems or pumped from wells. Also, lack of early season water availability may result in delayed planting (and resulting reduced yield) in dry years. Conversely, early season over-irrigation can leach nitrogen below the shallow root zone and reduce soil temperature, both of which potentially reduce yield. Local experience would indicate that in many areas of Southern Idaho, permission to start the irrigation water delivery season earlier would improve spring grain yield and quality. However, field data are required to convince the US Bureau of Reclamation (USBR) and Idaho Department of Water Resources (IDWR) that an earlier turn on time is justified.

OBJECTIVES

1. Based on field measurements, determine the reduction in crop yield and water use efficiency due to delayed early irrigation of spring grain.
2. Determine crop yield and quality for a range of last irrigation dates.

PROCEDURES

In both 1997 and 1998, the field portion of this study was conducted in cooperation with Harman Land Ranches on a field of Garland hard red winter wheat north of Rupert, Idaho. The majority of the field was irrigated with a center pivot, but the corners were sprinkler irrigated with handlines. Forty eight 12 x 60 foot field plots were located in the SW corner of a 160-acre field, with water supply from a well. Irrigation of the plot area was by Roberts Row Drip[1] bi-wall drip tubing spaced on 36-inch centers. Although not a common irrigation system in the area, surface drip irrigation was chosen because of the high water application uniformity, elimination of sprinkler overlap and wind drift, and ease of system automation it provided. Experiment design was random within the early and late season treatment blocks. Water inputs to the plots were measured by a municipal-type flowmeter and run-time data for each plot.
Soil samples were taken at one foot intervals to a depth of 4 feet (or rock if shallower) in mid-April for preseason water and nitrogen levels. Additional soil sampling for moisture conditions was done prior to each first-irrigation treatment and periodically throughout the growing season. Post-harvest soil moisture and nitrogen samples were taken at one-foot intervals to 4 feet or rock.

After irrigation began on a plot, irrigation scheduling was based on watermark moisture sensor readings and estimated crop water use. Watermark sensors were placed at depths of 1 and 2 feet in each plot, and were read 2-3 times per week. Estimated crop water use was obtained from the Mini-Cassia station of the regional AGRIMET automated meteorological network.

Prior to harvest, samples were taken to determine the number of heads per unit area and the number of seeds per head. An area 62 inches wide and of measured length (approximately 50 feet) was harvested from each plot on August 12 (August 18 in 1998) to determine plot yield. Four randomly selected areas from the adjacent handline irrigated area were also harvested. All grain from the harvest areas was collected and subsampled for test weight, protein content and hardness. Crop height was also measured at several locations per plot and averaged to obtain a representative height.

Date of First Irrigation

1997: Drip tape was placed on the soil surface in early April, secured by landscape staples at about 10-foot intervals and connected to individual plot manifolds. A manual valve on the manifold assembly was opened to initiate irrigation on each plot. Irrigation management after the first irrigation was identical on all plots and was scheduled using a combination of gravimetric moisture sampling and watermark moisture sensors placed at depths of one and two feet in each plot.

Four dates of first irrigation, replicated 4 times, were April 14, May 7, May 19, and May 28. The number of leaves on the mainstem, tiller 1, tiller 2 and tiller 3 for each first irrigation date were: <u>April 14:</u> 6.2, 3.7, 2.8, and 1.7; <u>May 7:</u> 8, 6.2, 5.3, and 4.2; <u>May 19:</u> 8, 8, 7.3, and 6.2; <u>May 28:</u> 8, 8, 8, and 7.5.

1998: The tape was pulled into the soil at a depth of about 3 inches in early April and connected to individual plot manifolds. A manual valve on the manifold assembly was opened to initiate irrigation on each plot. Irrigation management after the first irrigation was identical on all plots and was scheduled using a combination of gravimetric moisture sampling and watermark moisture sensors placed at depths of one and two feet in each plot.

Four dates of first irrigation, replicated 4 times, were planned. The plots were irrigated as planned on the

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[1] This information given herein is supplied with the understanding that no discrimination is intended and no endorsement by Cooperative Extension is implied.

first two dates, April 23 and May 8. After May 8, sufficient rain occurred to adequately water all the plots. Therefore, we could not have later dates of first irrigation. As a result, we used the plots scheduled for the last two irrigation initiation treatments as additional early dates of last irrigation.

Date of Last Irrigation

1997: Sufficient plot area was available for 16 more plots to study the effect of timing of the last irrigation on crop yield and quality. These plots were irrigated with the same tape buried about three inches deep, again on 36-inch spacing. Early and mid-season irrigation was identical to that for the April 14 irrigation initiation plots. Irrigation was stopped at 10 days before soft dough on one set of plots, at soft dough on a second set, and at 10 days after soft dough on a third set. The fourth treatment involved irrigating with mini-plot sprinklers instead of drip tape during a 20-day period beginning at 10 days before soft dough. The same depth of water was applied to both mini-sprinkler and drip plots.

1998: Sufficient plot area was available for 24 more plots to study the effect of timing of the last irrigation on crop yield and quality. These plots were irrrigated with the same tape buried about three inches deep, again on 36-inch spacing. Early and mid-season irrigation was identical to that for the April 23 irrigation initiation plots. Irrigation was stopped at each of 5 different dates on the drip-irrigated plots and 3 dates on the sprinkler plots as shown in Table 4. The same depth of water was applied to both mini-sprinkler and drip plots.

RESULTS

Early-season Irrigation

1997: Results of crop height, test weight, yield, protein content, and hardness are shown in Table 1 for the four dates of first irrigation and for the adjacent handline-irrigated area. Crop height was reduced in a consistent fashion as initial irrigation was delayed. Handline and April 14 treatments were the same, consistent with the fact that the date of first irrigation was the same. Although an obvious trend was present, statistically, there was no difference in crop yield for the first three irrigation treatments or handline treatment, with a reduced yield on the latest irrigation treatment. Degree of tillering, as expressed by the number of heads per square foot (data not shown) was essentially equal for the three earliest irrigation treatments, was about 19% less for the handline plots, and was about 13% greater for the last irrigation treatment. The higher number of heads for the last irrigation treatment was due to additional tillering when water was applied and development of many small heads that did not mature, or had low-test-weight grain at harvest. Protein content was the same for the first two irrigation treatments, and then increased with additional delay in first irrigation. Protein content was much lower for the handline treatment as compared with any of the drip irrigated treatments, although it appears that the difference cannot be explained strictly by wet vs. dry foliage (Table 3).

1998: Results of yield, test weight, crop height and number of heads per square foot are shown in Table 2 for the two dates of first irrigation, for the adjacent hand-line-irrigated area, and for a nearby portion of the center-pivot-irrigated field. Pivot and hand line data are given for reader information even though they cannot be statistically compared with the drip and sprinkler plot areas. Like the previous years, crop height and yield were reduced as initial irrigation was delayed, while test weight generally increased. Height on the handline and April 23 treatments were the same, consistent with the fact that the date of first irrigation was the same. As in other years, a good correlation was present between crop height and yield, although trends are hard to define with only two data points.

Late-season Irrigation

1997: Crop height, test weight, yield, protein content, and hardness are shown in Table 3 for the four late-season irrigation treatments and for the adjacent handline-irrigated area. For the first three treatments, irrigated with drip tape to give relatively dry foliage, yield was lowest at 10 days before soft dough and increased with soft dough and 10 days after soft dough irrigation cutoff, although there was no statistical difference between treatments 2 and 3. A statistically significant yield reduction was noted with the last irrigation treatment, which resulted in wet foliage. Of the grain quality parameters, the only treatment showing any significant difference was test weight for the first irrigation cutoff date, which was higher than for the other treatments. When combining this with yield information, the early cutoff prevented partial development of small heads so grain weight was higher.

1998: Crop yield, test weight, height, and heads per square foot are shown in Table 4 for the late-season drip and sprinkler irrigation treatments. Crop yield, height and test weight all show a general increase as the last irrigation is scheduled later in the season on the drip-irrigated plots. Yield and test weight increase as last irrigation is scheduled later for the sprinkler irrigated plots as well. No trend is present for the number of heads per square foot with either irrigation treatment.

Table 1: 1997 Irrigation Initiation Study on Garland Hard Red Winter Wheat, Harman Land Ranch: Minidoka, ID.

FIRST IRRIGATION	HEIGHT (in)	TEST WEIGHT (lb/bu)	YIELD (bu/acre)	PROTEIN (%)	HARDNESS
April 14	24.4 ab	58.15 a	127.97 a	12.02 a	71.83 a
May 7	23.3 b	58.00 a	125.95 a	12.05 a	69.37 a
May 19	21.1 c	57.48 a	120.72 ab	12.70 b	69.80 a
May 28	19.9 c	55.37 b	108.12 b	13.82 c	69.90 a
Handline (Control)	25.8 a	57.60 a	121.37 ab	9.2 d	56.43 b

* Values followed by the same letter are not statistically different at the 95% level as determined by the Students test.

Table 2. 1998 yield and crop characteristics for Garland winter wheat irrigation initiation plots, Harman Land Ranches, Minidoka, Idaho.

Date of first irrigation	Crop yield, bu/ac	Test weight, lb/bu	Crop height at harvest, inches	Number of heads per square foot
4/23/98 drip	129.8	59.8	30.4	150.4
5/8/98 drip	114.7	60.7	26.0	127.8
4/16/98 pivot	144.2	58.6	31.2	162.8
4/23/98 handline	113.2	58.1	30.4	163.5

Table 3: 1997 Last Irrigation Study on Garland Hard Red Winter Wheat, Harman Land Ranch: Minidoka, ID.

LAST IRRIGATION	HEIGHT (in)	TEST WEIGHT (lb/bu)	YIELD (bu/acre)	PROTEIN (%)	HARDNESS
10 d pre soft dough	24.2 a	58.95 a	120.32 a	12.40 a	65.68 a
Soft Dough	24.0 a	56.97 b	126.85 b	12.68 a	70.25 a
10 d post soft dough	24.8 a	56.95 b	128.52 b	12.55 a	68.72 a
10 d post soft dough, sprinkler	24.2 ab	57.28 b	115.10 a	12.25 a	70.52 a
Handline (Control)	25.8 b	57.60 b	121.37 a	9.2 b	56.43 b

* Values followed by the same letter are not statistically different at the 95% level as determined by the Student□s t test.

Table 4. 1998 yield and and crop characteristics for Garland winter wheat irrigation initiation plots, Harman Land Ranches, Minidoka, Idaho.

Date of last irrigation	Crop stage	Drip Irrigation				Sprinkler Irrigation			
		Yield, bu/ac	Test weight, lb/bu	Height, in	Heads/ sq ft	Yield, bu/ac	Test weight, lb/bu	Height, in	Heads/ sq ft
6/23/98	early milk	89.5	56.6	26.6	142				
6/30/98	16 days before soft dough	101.3	60.0	26.5	139				
7/6/98	10 days before soft dough	120.8	60.4	29.4	135	110.9	60.3	29.6	133
7/16/98	soft dough	125.1	60.6	29.9	158	114.3	60.5	29.0	150
7/26/98	10 days after soft dough	130.4	60.6	29.3	154	116.8	60.6	29.4	127